

**SENSORS AND TRANSDUCERS  
(AEIE 2102)**

**Time Allotted : 3 hrs**

**Full Marks : 70**

*Figures out of the right margin indicate full marks.*

*Candidates are required to answer Group A and any 5 (five) from Group B to E, taking at least one from each group.*

*Candidates are required to give answer in their own words as far as practicable.*

**Group – A  
(Multiple Choice Type Questions)**

1. Choose the correct alternative for the following:

**10 × 1 = 10**

- (i) A transducer converts  
(a) Mechanical energy into electrical energy  
(b) Electrical energy into Mechanical energy  
(c) One form of energy into another form of energy  
(d) None of the above.
- (ii) A series combination of thermocouples is used for the measurement of  
(a) Small temperature differences between two junctions  
(b) Large temperature differences between two junctions  
(c) Average temperature of a number of points  
(d) All of these.
- (iii) In a potentiometer, low value of resistance of potentiometer leads to  
(a) high value of sensitivity  
(b) low value of sensitivity  
(c) low value of non-linearity  
(d) low value of error.
- (iv) Chromel - Alumel thermocouple is typed as  
(a) J-type  
(b) T-type  
(c) K-type  
(d) E-type.
- (v) Which of the following acts as an active transducer?  
(a) Strain gauge  
(b) RTD  
(c) Thermocouple  
(d) LVDT.
- (vi) Which one of the following can act as an Inverse transducer?  
(a) Resistive transducer  
(b) Inductive transducer  
(c) Piezo-electric transducer  
(d) Hall effect transducer.
- (vii) The principle of operation of LVDT is based on the variation of  
(a) Self Inductance  
(b) Reluctance  
(c) Resistance  
(d) Mutual Inductance.

- (viii) In semiconductor type strain gauges, the change in resistance on application of strain is mainly due to
- (a) change in length of wire
  - (b) change in resistivity of wire
  - (c) change in diameter of wire
  - (d) change in both length and diameter of wire.
- (ix) Which of the following optical transducer is an active transducer?
- (a) photo-emissive cell
  - (b) photo-diode
  - (c) photo-transistor
  - (d) photo-voltaic cell.
- (x) LDR sensor is used to
- (a) monitor air pressure
  - (b) monitor motion of an object
  - (c) monitor light intensity
  - (d) None of the above.

### Group- B

2. As a load, a voltmeter with resistance  $R_m$  ( $\neq \infty$ ) is connected to a potentiometer. The excitation voltage of the potentiometer is  $E_i$ , the total length of the potentiometer is  $X_t$ , the wiper displacement from its zero position is  $X_o$ , and the total resistance of the potentiometer is  $R_p$ .
- (i) Determine the output voltage,  $V_o$ .
  - (ii) Determine the maximum input voltage if the heat dissipation is P watt.
  - (iii) How to improve the nonlinearity and sensitivity of the potentiometer?

[[CO2](Understand/LOCQ)]

6 + 3 + 3 = 12

3. (a) Determine the bridge sensitivity by drawing the full bridge circuit configuration for strain gauge.

[[CO4](Understand/LOCQ)]

- (b) How can you apply a capacitive transducer for angular displacement measurement?

[[CO6](Apply/IOCQ)]

6 + 6 = 12

### Group - C

4. (a) Define piezoelectric effect. Find the expression for voltage sensitivity of a piezoelectric transducer.

[[CO3](Understand/LOCQ)]

- (b) Draw the equivalent circuit of the piezoelectric transducer and hence analyse its frequency response.

[[CO1](Analyze/IOCQ)]

- (c) Mention two applications of series combination of piezoelectric transducers?

[[CO3](Understand /LOCQ)]

(2 + 2) + (2 + 4) + 2 = 12

5. (a) Define Hall Effect. Derive the expression for the output voltage of the Hall sensor.

[[CO2](Understand/LOCQ)]

- (b) A Hall effect transducer is used for measurement of a magnetic field of  $1.5 \text{ Wb/m}^2$  with a copper transducer for which the Hall effect coefficient is  $-52 \times 10^{-12} \text{ V-m/A-Wbm}^{-2}$ . The thickness of the element is 2mm and the current passing is 5A. Find the generated voltage.

[[CO2](Evaluate/HOCQ)]

6 + 6 = 12

**Group - D**

6. (a) Why is temperature compensation necessary for a thermocouple? Briefly describe any one industrially applicable process of temperature compensation. [[CO6](Analyse/IOCQ)]
- (b) A reaction vessel is divided into three sections at different temperatures. How would you measure the average temperature of the vessel? [[CO6](Analyse/IOCQ)]
- (c) The distance between the temperature sensing and measuring points is around 600 meters. What type of RTD configuration will be suitable? Explain with a neat and labelled diagram. [[CO3](Understand/LOCQ)]  
**(2 + 4) + 2 + 4 = 12**
7. (a) Compare between the industrial Thermocouple, RTD and Thermistor. What do you mean by Pt<sub>100</sub>? [[CO5](Remember/LOCQ)]
- (b) A platinum thermometer has a resistance of 100Ω at 25°C. Find the resistance at 65°C if the platinum has a resistance temperature coefficient of 0.00392/°C. [[CO2](Evaluate/HOCQ)]  
**(6 + 2) + 4 = 12**

**Group - E**

8. (a) What is a photo detector? Explain, using a suitable sketch, how a photo detector is used to measure angular speed. [[CO6](Apply/IOCQ)]
- (b) Describe how an ultrasonic sensor works. Explain the use of an ultrasonic sensor to measure the velocity of a flowing liquid with a suitable diagram. [[CO2](Understand/LOCQ)]  
**(2 + 4) + (2 + 4) = 12**
9. Write short notes on **any three** of the followings:
- (i) Photo diode
  - (ii) Photovoltaic cell
  - (iii) Semiconductor type temperature sensors
  - (iv) Smart sensors. [[CO1](Remember/LOCQ)]
- 4 + 4 + 4 = 12**

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	62.5	27.08	10.42

**Course Outcome (CO):**

After the completion of the course students will be able to

1. Acquire the knowledge of mechanical, electromechanical, thermal and magnetic sensors.
2. Explain the working principles of mechanical, electromechanical, thermal and magnetic sensors.

3. Classify sensors based on type of measurands such as strain, force, pressure, displacement, temperature, flow, etc.
4. Design the signal conditioning circuits for the sensors.
5. Justify the selection of Sensors and Transducers in the process of Measurement and instrumentation.
6. Use the sensors in various applications.

\*LOCQ: Lower Order Cognitive Question; IOCQ: Intermediate Order Cognitive Question; HOCQ: Higher Order Cognitive Question